QUARTERLY PROGRESS REPORT
DRD 875MA-003
October 2005 – December 2005

Marshall Space Flight Center
Safety and Mission Assurance Mission Services Contract
NAS8-00179

Approved:

Original signed by:

Randall S. Reed, Program Manager
MSFC S&MA Mission Services

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Hernandez Engineering, Inc.
Building 4471
Marshall Space Flight Center, AL 35812

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1.0 INTRODUCTION

Hernandez Engineering, Inc. (HEI) successfully performed all required activities and tasks, as described in this report, in fulfillment of their Safety and Mission Assurance (S&MA) Mission Services Contract (NAS8-00179) with NASA's Marshall Space Flight Center (MSFC). This report covers a three-month period of the contract's first quarter of the contract extension year: October 2005 through December 2005.

2.0 GENERAL MANAGEMENT

2.1 Data Requirements

The first quarter of the contract extension year of the S&MA Mission Services contract was successfully completed on January 1, 2006. All Data Requirements (DR) Documents were submitted on or ahead of schedule throughout the quarter. They included DRD 875CD-001 On-Site Employee Location Listing; DRD 875MA-002 Financial Management Reports; DRD 875MA-003 Progress Reports (Monthly/Quarterly); DRD 875MA-006 Operations Plan, Problem Assessment Center (PAC); DRD 875MA-007 Quarterly Open Problems List; DRD 875MA-008 Monthly Newly Opened/Closed Problem Summary; DRD 875SA-002 Mishap and Safety Statistics Reports; and Quarterly Safety Performance Evaluation.

2.2 Personnel Status

(b)(4) [redacted]

3.0 BUSINESS MANAGEMENT

We have experienced no financial or business management problems during this period. We attribute this to close attention to details, effective use of established controls designed to efficiently respond to program changes---both anticipated and unexpected---and the continuing support of our corporate financial group's dedicated efforts at controlling overhead expenses.

See the December 2005 Monthly Financial Report, DRD 875MA-002, for total costs specifics. Attachment 2, Man-Hours Expended, of this report contains a description, by major task, of the total man-hours expended this period. (b)(4) [redacted]

(b)(4) [redacted]

4.0 PERFORMANCE OF WORK AND USE OF FACILITIES AND EQUIPMENT

4.1 Safety

4.1.1 Industrial Safety (IS)

The Industrial Safety (IS) team performed ten OSHA compliance annual facilities inspections and provided all required reports in a timely manner, this completing the annual inspections for CY05. Also, IS prepared and submitted, for Industrial Safety Department (ISD) approval, the draft schedule of annual inspections for CY06, and performed 248 construction site compliance inspections to monitor adherence to OSHA and MSFC safety standards. All facility safety violations were documented in the SHEtrak database in order to assure MSFC's compliance with OSHA, NASA, and other consensus code requirements.

Among other activities, IS: (1) participated in four final safety inspections of facilities under renovation or construction; (2) in 45 facilities, performed on-site verification checks of findings reported closed by responsible organizations, this completing the verification checks for CY05; (3) reviewed 78 sets of facility design drawings for compliance with OSHA and consensus codes; (4) performed 38 annual fire drills; (5) taught three training classes to supervisors on how to perform monthly workplace safety visit inspections; and, (6) as a specific customer request, HEI (b)(4) who monitored construction and maintenance operations when working on energized systems for compliance with to proper Lockout/Tagout procedures. Although MSFC budget cuts led to a reduction from 3-4 days per week to one day per week during this period, 154 locations were surveyed.

In support of a new contract extension year SOW, formerly the S&MA Technical Directive Number 0131, IS continued to provide additional administrative and technical support to the MSFC SHE Committee to include: (1) assisted the SHE Committee Chairperson and ISD by supporting monthly SHE Committee meetings, which included collection and organization of pre-meeting briefing charts, serving as recorder and preparation of draft meeting minutes; and, (2) entered SHE action items in CAITS. Also, in coordination with the ISD and the HEI IM team, IS initiated implementation of this contract years Area of Emphasis (AOE) to test the new Risk Safe software in support of the Hazard Assessment Process.

IS initiated, completed or followed-up on numerous facility safety assessments (SA) and associated hazardous operations reviews. Examples include: (1) prepared an SA for the Booster Separation Motor (BSM) proposed testing at TS116; (2) initiated an SA for the Low Element Density (LED) testing at 40K position at TS116; (3) continued to prepare the SA for the Return to Flight (RTF) Heater Panel testing with Liquid Hydrogen at B4699; (4) continued to support the Micrometeoroid/Space Debris LGG in B4612; (5) continued to support the ECLSS operations in building 4493; (6) supported the TRR - Flow Augmented Thermal Mgt - Entry and Reentry Environments, B4732; (7) continued to provide support to the KT-Engineering Phase II Testing at Test Stand 500; (8) reviewed SA for the Hot Fire Test Trailer (HoFiTT) in building 4656; (9) reviewed the risk assessment and JHA for the Sodium Heat Pipe Electron Beam in Bldg 4705; and, (10) reviewed/revised the SA for the Laser Operations at the METCO Arc Jet Facility at Hot Gas.

IS continued to support the implementation of the NASA lifting standard, NASA-STD-8719.9 by providing day-to-day advice and assistance to S&MA customers. IS advised civil service and contractor managers, supervisors and employees on requirements for lifting equipment usage in support of the MSFC SHE Program. Also, IS continued to be an active participant in the Lifting Device Equipment (LDE) SHE Subcommittee. In support of the task to administer proficiency exams to civil service and contractor operators of overhead cranes, fork lifts, small truck mounted hoists, and aerial lifts, IS administered hands-on proficiency examinations to 24 aerial lifts, 17 overhead crane and 20 forklift operators in support of the MSFC Personnel Certification Program, MWI 3410.1. In CY05, IS performed 142 proficiency exams.

As a continued significant strength, IS (b)(4) (b)(4) Examples of support included: (1) reviewed and approved multiple operating and test procedures for hazardous operations; (2) reviewed the Quantity–Distance (QD) requirements for the Booster Separation Motor (BSM) proposed testing at TS 116; (3) prepared QD calculations for the test program P-2504 "LOX/LCH4 Thruster testing at TS 115"; (4) actively participated in daily and weekly safety meetings/safety stand downs of the MSFC East and West Test Area, S&MA Safety and Quality team and the Engineering Directorate's Test Laboratory; (5) as an additional duty, IS served as the alternate safety representative for test area facilities; and, (6) provided daily support to test engineers and S&MA personnel on technical issues to include performing numerous test procedure reviews.

(b)(4) continued their outstanding support to SSC S&MA by preparing system safety analyses and presenting test readiness review analysis data to meet Propulsion Test Directorate compliance requirements at the E-Complex Test Facility. Programs and projects assessed and continue to be assessed included: IPD (Integrated Powerhead Demonstrator), Advent Engine Test Project, ITA (Instrumentation Test Article), HMTP (Hybrid Materials and Gas Generator), Methane Thruster Test Project, E2/E3 Facility System Hazard Analyses and Mission Essential Fire Protection Systems. Examples of the technical support function included: participating in design reviews, facility upgrade reviews, weekly telecoms, technical interchanges, scheduling and sidebar meetings, delta tabletop discussions, etc. In addition, the team actively participated in SSC post-hurricane recovery efforts by gutting houses, removing trees from homes, working in distribution warehouses and performing site inspections for the location of FEMA trailers. The team also participated in design reviews and site inspections of FEMA trailer communities.

4.1.2 System Safety Engineering (SSE)

System Safety Engineering (SSE) supported the Marshall Safety Engineering Review Panel (MSERP) as Executive Secretary, Integration Representative, Senior Consultant, and Technical Writer. SSE wrote the minutes of the meetings, reviewed hazard reports, presented current change requests and their effects on hazard reports and Critical Item Lists. SSE supported a conference of all the Safety and Engineering Review Panels (SERPs) in Houston, December 12-14, 2005. The meeting included discussions of the charter with respect to each SERP, common SERP issues such as inter-panel integration, periodic review of hazard reports, opening hazard reports, and support from institutional organizations. SSE supported Technical Interchange Meeting to discuss proposed updates to SSP 22254, "Methodology for Conduct of Space Shuttle

Program Hazard Analyses", reviewed the document, provided comments and compiled comments.

SSE supported: (1) creation of Marshall Directive Documents that will describe the structure and function of the MSERP and its relation to other Safety and Engineering Panels; (2) built up the Process Based Mission Assurance (PBMA) web site and made it as user friendly as possible.; (3) supported weekly MSERP internal meetings to discuss plans and strategy and meetings to review element presentations; and, (4) supported ET Frost Ramp Fault Tree Block Closures.

SSE supported the regular meetings of the elements and reviewed documents pertaining to safety, provided closure for MSERP actions assigned before return to launch STS-114, reviewed and evaluated hazard reports related to integrated and element hazards discussed during the reporting period, and, evaluated and assessed a Technical Interchange Meeting (TIM) on Nozzle-to-Case J-Leg Redesign.

SSE developed and presented two presentations regarding Problem Reporting and Corrective Action (PRACA) In Flight Anomaly (IFA) closure rationale for STS-121.

The SSME SSE is continuing to evaluate additional new SSME FMEA/CILs that incorporate, hazard report updates, and the corresponding fault trees, for the AMHS controller upgrade.

SSE supported post-launch ET foam loss investigation, reviewing ET Hazard Reports and CILs and attending daily S&MA meetings.

SSE assessed S&MA requirements applicability to *In Situ* Fabrication and Repair (ISFR) activities for both the fabricators and products to be produced on the moon and Mars. For products produced on the moon or Mars the PAE analyzed these requirements from the stand point of impact to the design of materials and parts derived from in-situ resources from the moon, Mars, asteroids, or other Constellation Program destinations in addition to fabrication using terrestrial source stock.

SSE supported several CLV meetings, human factors requirements flow down to the CLV meetings, and Requirements meetings. SSE supported the Ascent Flight System Integration Group (AFSIG) Panel meetings on December 9-16, 2005. Several trade studies are still under way that need to be completed to support the upcoming DAC.

SSE contacted KSC S&MA for CLV, and provided safety inputs to the CLV to Launch Management System (LMS) Interface Requirements Document (IRD).

SSE reviewed and commented on Constellation Level II Safety Requirements, and supported Range Safety documentation evaluation.

SSE held several meetings to develop fault tree for CLV. SSE continued development of the fault tree, providing comments and suggestions based on experience gained in the development of Fault Trees for other programs. SSE updated the schedule for completing a draft fault tree for SRR. SSE continued a literature search and document review for failure modes to support fault

tree and hazard analysis. SSE supported meetings between the project office and S&MA to discuss integrated hazard analysis and the fault tree.

SSE supported mid-term trade study meetings, supported the Stage Separation trade study meetings., and provided safety input to the trade study.

SSE supported the Reliability Based Design team meetings. As part of a team action to quantify the potential improvement in CLV reliability for the added redundancy in a Two Fault Tolerant Requirement (Fail Operational, Fail Operational, Fail Safe), SSE characterized the current Accepted Risk hazard causes in the Heritage hardware hazard analyses.

SSE supported the special Orbiter Configuration Control Board (OCCB) to discuss the Thermal Protection System repair options. SSE drafted a fault tree covering the variation in repair material viscosity. The fault tree was reviewed by the ROCR team and then presented to a Quality team to help determine a plan of action to control viscosity variation.

SSE delivered a draft of the ECLSS Ground Safety Data Package (GSDP) for review. This package incorporates the latest decision for processing the ECLSS OGS at KSC.

SSE prepared: (1) a revision to the Reflown Safety Data Package for Microgravity Science Glovebox resupply items scheduled for ascent on ULF1.1; (2) a revision to the MSG Phase III hazard report MSG- FL4, "N_2 Rich Atmosphere in the MSG WV", and, (3) a draft Safety Data Package for the Microgravity Science Glovebox Scavenge Pump Battery manifested to be flown on Utilization Logistics Flight 1.1. SSE evaluated the hazard assessment submitted by the European Space Agency (ESA) for on-orbit replacement of the MSG Front Window Assembly.

SSE received comments to the Node 3 hazard reports from the Node 3 team and incorporated these into the reports. These reports were then submitted to JSC for the delta phase II review in January 2006.

SSE reviewed documents submitted by Alenia or NASA to verify that they can be used to close items in the Safety Verification Tracking Log (SVTL) for Node 2. Fifteen additional items have been closed on the SVTL, leaving only 84 remaining open. Of these 84 about 20 will be open until final hatch closure.

SSE supported the Node 2 Quarterly Review held at KSC. There were no direct safety issues that were presented, but in the future the International Space Station Program structures group and will have discussions on the proper definition of safety critical fasteners.

SSE updated to the remaining five Node 3 hazard reports that are to be submitted for the delta phase II review. These reports were transmitted to JSC.

SSE supported the OGS team meetings, and the Video Conference with the International Space Station (ISS) Safety Review Panel (SRP). This conference was set up as an overview presentation in support of the formal review. SSE updated the ISS SRP safety presentation for the flight safety review based on comments provided by the Project.

SSE made updates to the Oxygen Generation Assembly (OGA) Safety Verification Tracking Log (SVTL) used to track the status of all of Hamilton's safety verifications and completed updates to the OGS SVTL based on data from the OGA SVTL. SSE put together burn down charts for QD30 and continued its work on tracking the status of all of the S&MA verifications and coordinating their closure, and submitted OGS Spec verifications and safety verifications.

SSE supported the normal Urine Processor Assembly (UPA) and WRS team meetings. SSE also supported WRS Phase III safety review with the International Space Station (ISS) Safety Review Panel (SRP). Nine hazard reports were presented and five were signed. The remaining four were technically approved but require minor modifications based on discussions that occurred during the review.

SSE worked leak-before-burst requirements for the MSRR-1 Thermal and Environmental Control System (TECS) shelf. The TECS shelf will be removed from the rack as an orbital replacement unit and will contain water that is not pressurized. The concern is the effect on the system if it experiences a temperature increase and/or rapid depressurization. SSE researched asphyxiant sampling requirements for the MSRR-1 prior to initial on-orbit power up.

SSE completed revision of the Series Integrated PromISS-4 Flight Safety Data Package according to out-of-board comments received from the Payload Safety Review Panel (PSRP). The revised package has been transmitted to the PSRP.

SSE updated GLAST Burst Monitor (GBM) Preliminary Hazard Analysis and incorporated into a Safety Assessment Report. This report has been submitted for approval.

SSE presented "Flight System Safety: A Program Life Cycle Challenge". This presentation is the forerunner of a paper being developed for utilization by the system safety community. The initial presentation addressed the four basic domains that are sources of safety hazards/risks and two case histories from the Apollo Program. The second half of the presentation will address two shuttle case histories and the factors in program end-of-life conditions drawn from issues faced by the Skylab and Hubble Space Telescope programs.

SSE coordinated the Safety, Reliability, and Quality Assurance presentations to the SLaTS IX, S&MA session on December 1, 2005.

SSE continued with method evaluations and collection of government, industry, and academic procedures for the performance of software safety tasks, e.g., Software Fault Tolerance Analysis (SFTA), Reliability, etc. The intension of this analysis is to determine which methods may be useful to MSFC and to develop corresponding detailed procedures for implementing and/or assuring the software safety requirements of NASA-STD-8719.13B and NASA-GB-8719.

As part of the HEI Training, System Safety Engineering (SSE) prepared and presented a training session on Basic Fault Tree Analysis. The 3 hour session was held on Oct 20th and is the third presentation on this subject.

4.2 Reliability

4.2.1 Reliability & Maintainability Engineering (R&ME)

During the this quarter Reliability and Maintainability Engineering (R&ME) continued to support the Constellation Program (QD10) through its involvement in meetings and telecons regarding reviews, comments and revisions in order to provide status, discuss recent issues and possible future changes/modification to the Constellation Program's FMEA/CIL Methodology requirements document. As a result of such involvement R&ME reviewed the top level CLV Reliability Allocations for this reporting period and revised its draft this quarter of Revision A of the FMEA/CIL Methodology document. These revisions were based on comments and updates received via inputs to the FMEA/CIL change log. R&ME currently awaits a response from KSC on GSE issues, which is required before the document can be finalized.

R&ME assisted with performing a Fault Tree Analysis (FTA) and creating an initial Fault Tree (FT) for the CLV project to review in January 2006. R&ME remains in the initial phase of the FTA but has met with MSFC S&MA to do an internal review of the top level FT before engineering reviews/comments on it. R&ME also attended the MSFC S&MA CLV meeting to discuss progress of the FT and the schedule for the second quarter of Fiscal Year 2006. R&ME is awaiting the go-ahead from MSFC's project office before proceeding with further development efforts of the FT.

R&ME supported the kick-off meeting for the CLV Risk Based Design (RBD) Integration Group held this quarter. The RBD Integration Group is chartered under the CLV Vehicle Integration and is tasked with implementing and coordinating the reliability, maintainability, supportability, integrated hazards, costs and operations for the integrated CLV stack, across all the CLV elements with Level 2 and within the Vehicle Integration Office.

R&ME met with other members of the Upper Stage Green Run Trade Team this quarter to assess whether or not hot-fire testing would be required as a part of the Qualification Test Requirements. This concern was raised by the Upper Stage Project Office due to the current version of the CLV Con-Ops document requiring that each flight's Upper Stage be hot-fire acceptance tested (green run) with its Upper Stage engine before every launch. The outcome of this decision will have significant impacts on the CLV's Logistics, Costs, and Test requirements.

R&ME continued to provide dedicated support this quarter to QD20's Reinforced Carbon-Carbon (RCC) Crack Repair Material (CRM) project by updating the FMEA/CIL and P-FMEA's for the "Safe to repair" Risk Assessment Executive Summary Report (RAESR).

R&ME continued with its S&MA support to the Space Shuttle Program's ET by following the Verification & Validation (V&V) process for the Protuberance Air Load (PAL) automated spray process and discussing/updating resulting issues with the ET's Project Manager. R&ME participated in several special meetings held between the TPS Process Control Board Technical Subcommittee and MSFC TPS concerning the PAL automatic ramp spray process. Due to required testing this process has not been developed to the point where an automatic PAL ramp can be sprayed for the next flight (STS-121). A decision has been made to continue SDS on automatic spray and to use enhanced manual spray for ET-119. Present concerns around

automatic spray systems are centered on the spray-gun's reliability for the duration of a full PAL ramp spray and the stability of the robot/ structure during the spray application. However, plank and gun tests have been scheduled to verify foam thermal and mechanical strain conditions and spray-gun reliability. R&ME has also been involved in the Aero Vent Redesign effort requiring an investigation into a design change that is to remove some of the TPS foam around the Aero Vents on the inter-tank area of the ET. R&ME is currently developing a presentation for the ET Project Office in order to discuss and determine the pros and cons of flying with PAL ramps removed vis-à-vis PAL ramps in place. R&ME has assessed the reliability impact of flight without PAL ramps and has provided inputs for a test plan and procedure that will ensure reliability, feasibility, and validity of tests to be performed.

R&ME participated in this quarter's ET Engine Cut-Off (ECO) Anomaly TIM in order to establish testing procedures and plans for determining the most probable cause(s) for anomalies resulting in the scrub of first launch attempt (STS-114) following the loss of Columbia. R&ME provided inputs to the test plan and procedure to ensure reliability, feasibility, and validity of tests to be performed. R&ME also reviewed the tests to determine whether they were bench, system, or component level.

R&ME supported the Space Shuttle Program's SSME Integration Hazards Update conducted in Canoga Park, CA. This three day SSME Hazard review update was in response to action items generated from newly developed post STS-107 reports. The reports that were reviewed and updated dealt with inadvertent hydrogen released through the nozzle, loss of thrust, nozzle burn-through and rupture explosion.

R&ME supported Pratt &Whitney/ Rocketdyne in an AHMS Hazard Report Peer Review this quarter in Canoga Park, CA. The goal of this peer review was to complete a detailed scrubbing of the Hazard Reports affected by the addition of the AHMS to the SSME controller. The Hazard Reports review included ME-A1P; ME-B2S; ME-B4S; ME-B6S; & ME-D1S, M. These reports were scrubbed for technical and editorial type changes.

R&ME provided support to QD22 by participating in the review and Fault Tree closure of six In Flight Anomalies (IFA's) which were identified by the SRB Element. One of the IFA's was exonerated as pre-existing prior to launch and another as a post separation event. The four remaining IFA's have opened Fault Tree blocks and are being worked through test and analysis. The estimated closure for all remaining IFA's is scheduled for January 2006. R&ME also supported the SRB S&MA lead in briefing the IFA's to S&MA's upper management. R&ME also routed and reviewed the Certificate of Qualification (COQ) for the upgraded IEA wire harnesses this quarter. The paperwork was in order and the correct reports were placed in the package at the request of R&ME. S&MA is now awaiting concurrence and signature from the SRB Project Office to officially close out this COQ review process.

R&ME provided an assessment of the material that was presented in the Joints 2 & 5 Carbon Fiber Rope (CFR) and Joint 5 bolt redesign DCR held this quarter. The implementation of the CFR in Joints 2 & 5 will serve to replace the current sealant and to allow these joints to pressurize in a controlled fashion, at motor ignition, and remove heat from the combustion gases flowing through the CFR. The use of the CFR will simplify joint assembly and reduce both

assembly and refurbishment timelines. The RSRM nozzle joint 5 bolt redesign will reduce joint skip, eliminate bolt bending, and washer plastic deformation. The new bolt material will also mitigate the possibility of Hydrogen embrittlement and stress corrosion cracking. Review of the associated FMEA/CILs resulted in an R&ME action to clarify four areas of the FMEA/CIL retention rationale.

R&ME was a participant during two RSRM design changes that were presented to the MSERP this quarter: TIGA implementation and removal of the Igniter Initiator Inner Diameter Insulation Strip. TIGA adhesive bonds the nozzle glass cloth phenolic to the nozzle metallic housing and is being implemented due to obsolescence of the current adhesive. The Igniter Initiator Inner Diameter Insulation Strip is being removed to eliminate un-bonds routinely identified between this strip and the metal initiator chamber. Analysis of this change indicated neither performance nor reuse will be affected. The updated Critical Item List (CIL) and Hazard Report revisions for both the TIGA and Igniter Initiator were approved by the MSERP board.

R&ME along with MSFC RSRM S&MA and ATK-Thiokol System Safety conducted a Technical Interchange Meeting (TIM) this quarter at MSFC. The main topics discussed were the development of flight rationale, risk assessment and terms as they pertain to the CoFR process and Material Review Board Assessments. ATK-Thiokol presented the methods of completing a matrix containing the seven elements for good flight rationale. The matrix was later incorporated into hardware change request evaluations performed by MSFC RSRM S&MA.

R&ME Integration continued to support the regular Operations and Maintenance Requirements and Specifications (OMRS) Working Group this quarter by coordinating all of KSC's comments concerning RCN MB16853. This RCN was written to add motor case GEI temperature sensors to the checkout list. These sensors are being added to the RSRM Case Temperature Launch Commit Criteria (SRM-11) by LCN 1158R02 to NSTS 16007, REV. H, Change No. 57, which was approved by PRCB Directive S072380EP, dated July 7, 2005. The R02 version however incorporated administrative changes but did not change the technical content. R&MEI noted that LCN 01158 identified the measurements as "CRIT 1" while RCN MB16853 identified the verification of these measurements as "CRIT: NONE". ATK-Thiokol, RSOC Integration, SRB, SAIC and JSC were all contacted concerning this inconsistency, recommending that it be resolved. ATK-Thiokol believed that this requirement was a "Criticality NONE"; citing several requirements along with a general requirement and S00FA0.610, S00FA0.776 and S00FA0.777 that show coverage of the criticality issue even though those requirements do not specifically call out the measurement numbers. ATK-Thiokol along with Reliability and System Safety Engineers have responded and agreed that there was indeed an inconsistency between the OMRSD and LCC and that it required resolving. A formal evaluation of this change was submitted in order for a mail message to be released into the OMRSD system.

R&ME finalized its REGEN ECLSS Wiring Harness/FMEA cross-matrix this period. The final version has been distributed to all applicable program personnel for review and comments. In addition R&ME verified with MSFC S&MA personnel that the completed REGEN ECLSS OGS/GSE (Vacuum Pumping Cart) Process FMEA was sufficient for them to support the waiver necessary to initiate the OGS Rack testing utilizing the Vacuum Pumping Cart. R&ME has also

updated the REGEN ECLSS OGA FMEA/CIL report this quarter received from Hamilton Sundstrand October 3, 2005 and organized all aspects of the updated analysis, including the conversion of the Excel FMEA worksheets, to a word format and posted the final/fully approved versions of the OGS FMEA/CIL Analysis, OGS Maintainability Analysis, and OGS Limited Life Items List on the ECLSS website. R&ME is currently working with JSC ISS R&M Panel Chair and Boeing/Huntsville R&M personnel on the processing of these updated documents.

Per direction from ECLSS Project Management, the focus this quarter has been on OGS documentation updates in preparation for a potential January 2006 delivery date to KSC. R&ME has also been very involved in this quarter's requirements verification activities of the OGS System. A total of twelve are now closed, two being closed with changes to the requirements documentation. Verification work continues on two remaining requirement.

R&ME is currently working to complete the Material Science Research Rack (MSRR-1) FMEA/CIL analysis. In reviewing the current FMEA worksheets it was determined that R&ME was lacking appropriate drawing references and that a specific entry was required to access the top level SSPCM assembly drawings. R&ME has since contacted MSRR-1 Engineering regarding this information as well as Time to Detect Failure (TDF) data, in order to assist with the scoping of these tasks which are now in progress. In the interim R&ME has submitted its FMEA spreadsheets to MSRR-1 Engineering in order to solicit any comments, corrections or additions on the work analysis performed to date, and has also coordinated with the U.S. point of contact (Sverdrup) to have the MSRR-1's FMEA work sheet for the Material Science Laboratory (MSL) sent to European Space Agency's (ESA) in order to gather additional information on the sub-system. A response is not expected from ESA until January 12, 2006.

R&ME has coordinated its efforts along with QD40 S&MA, Goddard Space Flight Center (GSFC), and members of the MSFC GLAST BURST MONITOR (GBM) Project Office this quarter for completing the Data Item Descriptions (DID's) on GBM. R&ME has one remaining action concerning its already completed preliminary FMEA (DID 311) which is to re-write the analysis explaining that all parameters were set at the worst case limits, that worst case environmental stresses for all parameters were considered and that all operations were evaluated. This task is expected to be completed by the end of January 2006.

R&ME continued as an active member of the International Space Station (ISS) Reliability and Maintainability Panel this quarter, held jointly each week with JSC to ensure that R&M programmatic and technical requirements are implemented within each program/project.

4.2.2 Problem Assessment Center (PAC) Operations

HEI's PAC personnel processed and coordinated disposition of problem reports; coordinated the MSFC Problem Assessment System; performed and coordinated problem processing; instigated and implemented STS-114 Integration IFA processing into MSFC PRACA; worked in the NESC PRACA Taxonomy Working Group to define minimum data fields for future programs; suggested, monitored development, and reviewed enhancements to the MSFC PRACA data system; and operated the Corrective Action System (CAS). The PAC received and entered 64 new problem reports (PRs) into MSFC's Problem Reporting and Corrective Action (PRACA) System, coordinated MSFC interim closure of 5 PRs, received 25 prime contractor closure

recommendations, supported MSFC full closure of 21 PRs, coordinated non-problem closure of 2 problems, performed 868 individual PR database updates and reviews, and made special date adjustments to 12,169 SSME problems while implementing the Prior Use Date field. The PAC conducted 3 SSME problem review boards (PRBs) resulting in dispositioning 13 problem reports. The PAC reviewed 5 requests for access to the MSFC PRACA database and granted all of them. The PAC requested and monitored implementation of enhancements to the MSFC PRACA data system, including automation of daily and weekly open-against-next-mission Shuttle problem summary reports, query on NULL and NOT NULL value contents, customizing the data system to receive and house SE&I IFAs, adding the SSME Prior Use Date field, and adding Cycle Time as a selectable field in customer reports.

In support of the Shuttle Program Assurance Office, the PAC worked through the Shuttle PRACA Working Group in establishment of common hardware problem identification and notification, PRACA data clean-up, and development/review of PRACA training materials. The PAC also advised Shuttle Assurance, contractor, and/or Shuttle Program Assurance personnel regarding PRACA reportability and processing of In-Flight Anomalies. We generated and distributed a weekly open PRACA problems and ALERTs metric to show progress toward resolution of all issues prior to shuttle missions. We also coordinated MSFC review of a NSTS 08126 PRACA change request regarding risk, trending, and IFA time frames; offered suggestions for improved wordings; and led MSFC's participation in a teleconference on those revisions that resulted in withdrawal of the initial change request (viz.., CR S063211).

In support of the Constellation System (CS), the PAC represented MSFC and the Constellation Program on the NESC PRACA Taxonomy Working Group. The task performed and accomplished by this group was to define a minimum set of data fields, clearly define them, and explain their use with typical values, itemized lists, and (for free-form text fields) layouts/templates. Participation included participation at a face-to-face group meeting at Langley, numerous teleconference discussions, submitting specific wordings for at least four specific areas (including recommended Problem Description text contents, definitions for nonconformance/anomaly/discrepancy, clarification of differences between and typical options for remedial actions/recurrence control, when in processing flow the various data fields were expected to be populated, and report status options). This was in addition to leading input from shuttle-based lessons learned and participating in general group discussions regarding re-wordings, clarifications, and final report proofing. The PAC also provided supporting documentation regarding Shuttle PRACA and the Constellation PRACA Methodology to Ames (per direction from Constellation S&MA) to assist them in developing analysis for a proposed Constellation PRACA data system application.

The PAC provided various problem data in support of NASA and MSFC analyses. Regular activities included providing daily KSC PRACA shuttle problem summaries, daily MSFC PRACA open-against-next-mission summaries, daily KSC Resident Office reports, monthly newly opened/closed problem summaries, weekly SRB PRACA and ALERT activities and status reports, and quarterly Open Problems List (OPL). In working with the Shuttle webPCASS consolidated data system, the PAC twice identified discrepancies with their storage of MSFC PRACA data and worked with the webPCASS support contractor to correct the issues involved

and even expand MSFC data participation by providing Adobe Acrobat supporting data file attachments to MSFC PRACA problem reports.

In special engineering analyses activities, Problem Assessment Engineering (PAE) initiated the review and edited approximately 300 SRB PRACA database records to correct and/or standardize the Nonconforming Article (NCA) Nomenclature, NCA Part #, and System fields. This task was performed to enhance search and assessment capabilities. Efforts included various data sorting methods, consulting with engineers, reviewing online PRACA records, PAC archive PRACA folders, and FMEA/CIL documentation, and initiated a discussion with Rocketdyne/Pratt Whitney concerning the compliance of RF0004-004 and NSTS 08126 in the area of the Fail Date, Isolation Date, and the Problem Report and Management System (PRAMS) date. After the discussion with Rocketdyne/Pratt Whitney, it was decided to revise the dates. A significant portion of the clean-up was done with software and PAE is in the process of revising/replacing what could not be done automatically. These changes will help to correct the SSME PRACA database, and perform an SSME Contamination Data Search that found 80 related Unsatisfactory Condition Reports (UCR's) from 01/01/2003 to 10/10/2005. An additional search of KSC PRs for contamination found during post-flight inspections was provided that included the 25 missions previous to STS-107 with the number of PR's written against each flight engine. Based on these findings, an in-depth study was performed on information relating to types of contamination, where contamination was found, and whether UCR's were written as a result of the PR's.

In problem trending, PAE continued to apply and improve techniques for recurring problem identification, analysis, and presentation and to enhance automation of steps in the process. The PAC continued to work with Shuttle Program Assurance, the Shuttle PRACA Working Group, MSFC and JSC Reliability, and the NESC Data Mining and Trend Analysis (DM&TA) Working Group to define a common approach to trending for use across the entire Shuttle Program. In support of the NESC DM&TA Working Group, the PAC reviewed a text mining application developed by Ames and offered suggestions for improvement in the user interface and initial query capabilities.

In implementation and operation of the MSFC CAS, PAC : (1) received 33 potential CAS reports; (2) screened 32 draft Recurrence Control Action Request; (3) elevated one to a new Recurrence Control Action Request (RCAR): (4) coordinated there point of contact (POC) responses: and, (5) facilitated four Corrective Action Boards (CABs) resulting in closure of four RCARs. In response to an audit finding by NQA, PAC resolved DCB review comments to MPR 1280.4, MSFC CAS Operation, obtained DCB approval, and obtained NQA closure to the associated minor nonconformance. In a separate issue, PAC implemented expanded documentation for RCAR statusing as a way to address an NQA observation.

4.2.3 ALERT Program

HEI's ALERT support included both regular and special activities as HEI ALERT coordinated MSFC ALERT processing and participated in the NASA and general Government-Industry Data Exchange Program (GIDEP) activities. HEI ALERT received and distributed 40 ALERT announcements for MSFC review and obtained 2,347 responses from MSFC project, contractor, and laboratory contacts. HEI ALERT support personnel: (1) reviewed and approved eight new

MSFC ALERT database accounts via the TPS security; (2) generated monthly Open, Delinquent ALERT response tabulations and provided them to S&MA and/or Directorate single points-of-contact responsible for open ALERT reduction; (3) adjusted MSFC ALERT participation to match the changing MSFC Directorate and Project assignments; (4) compiled, formatted, and submitted the annual GIDEP utilization report for MSFC, documenting $150,000 of cost avoidance; (5) maintained a low delinquent response level (maintaining 100 or less delinquent responses for the last 2 month); and, (6) reviewed, exercised, and evaluated the preliminary system and developed and reviewed documentation for a preliminary release of a NASA Advisory Forum database application in support of the NASA ALERT Coordinator and MSFC and other NASA center ALERT personnel. The PAC also provided monthly ALERT data and meeting support to the MMS Implementation Team and to the Management Safety Review (MSR).

4.3 Quality

Space Transportation

Space Shuttle Main Engine (SSME) Quality Engineering (QE) developed an element Government Quality Plan and Implementation Matrix which addressed how SSME S&MA complies with NSTS 60538.

SSME QE traveled to Canoga Park, CA and participated in the MSFC Configuration Audit of Pratt and Whitney Rocketdyne. The MSFC team documented eight finding and eight observations.

SSME QE participated in the Non Integral Ignition System (NISIS) Cover Critical Design Review. This cover is being added to protect the electrical components sensitive to cold inside the NISIS Box.

SRB QE traveled to KSC for orientation to personnel and facilities. Some of the facilities visited were the Assembly and Refurbishment Building, Vertical Assembly Building, and Hanger A-F.

SRB QE continued to support the BSM graphite throat Factor of Safety (FOS) tiger team meetings. QE continued day-to-day activities which included support to weekly Booster Separation Motors (BSM) Integrated Process Team (IPT) meetings, BSM Plume Characterization Team, RTF Action Review, and RTF Technical Interchange Meetings. QE prepared and presented technical issue briefings to S&MA upper management.

SRB QE continued to support to the Automated Dynamic Acceptance Procedure Test Stand (ADAPTS). QE finalized the Operations Manual and Maintenance Manual.

SRB QE continued participation in the SRB ATK Booster Separation Motor (BSM) Alternate Source Team activities. This has included support of Readiness Reviews (TRR) and technical interchange meeting to resolution of open review item discrepancies.

SRB Pyrotechnics supported the Pyrotechnics S&MA in the review of SRB Phase II documentation of Frangible Nut Booster Cartridge redesigned, the Frustum Separation Linear Shaped Charge Bushing Rotation Problem Investigation, the hardware process audit at Ensign

Brickford Aerospace and Defense Company, the Confined Detonating Fuse Manifold Residual Masking Material Issue, and the Waiver, Deviation and Exceptions Review.

SRB QE supported the Integrated Product Team (IPT) Integrated Electronics Assembly (IEA) Supportability Upgrade Team and the Lead Free Solder Project Joint Workgroup for Pollution Prevention.

SRB QE developed an element Government Quality Plan and worked with the ROM Office to develop an audit checklist to be used to prepare for an up-coming audit of their compliance with NSTS 60538.

ET QE continued to support the Excitation Power Box (EPB) Instrumentation activity, providing quality requirements and receiving inspection instructions as required.

ET QE continued to support the PAL Ramp Investigation Team activities. Primary role is providing quality engineering support to the 5 investigation teams (BiPod, Ice Frost Ramp, Flange, and Acreage) and the test facilities.

RSRM QE supported a Silicon Contamination Technical interchange Meeting with ATK Thiokol. ATK presented a proposed test program and management plan to identify critical processing areas and procedures for silicon contamination.

RSRM QE developed an element Government Quality Plan and Implementation Matrix which addressed how RSRM S&MA complies with NSTS 60538. This document was approved on 11/15/2005. An audit was performed by JSC Shuttle Quality on 11/8-9/2005 at the ATK Facility with RSRM RMO, RSRM DCMA, and RSRM QE personnel. At the completion of the audit no finding were noted.

QE commenced support to the S&MA Launch Systems Assurance Department, providing personnel to the Launch Vehicle Integration team and the Upper Stage.

Software Assurance

Software Assurance (SA) continued to support the Material Science Research Rack formal verification and validation testing of flight software Operational Increment 3.0.3.4. Also, SA participated in the Software Engineering Institute Capability Maturity Model Integrated Level 2 Assessment.

ISO/AS9100

QE has continued to play a key role in ensuring the maintenance of ISO 9001 and AS9100 at MSFC during this time period. Efforts have dealt with continuing implementation of ISO 9001 and AS9100, maintenance of documentation, and planning and support for the NQA registrar surveillance audit, including escorting during the audit, and follow-up and closure of corrective actions. QE provided general ISO and AS9100 support, including Integrated Management System Board (IMSB) meeting preparation; reviews of both MSFC and NASA Agency documentation; and consulting support on internal audits, continual improvement, customer

satisfaction, quality objectives, management review, and other aspects of ISO 9001 and AS9100 to various MSFC Organizations.

Payloads
QE performed drawing reviews, procedure reviews, test readiness reviews, and procurement reviews, inspection requirements, shipping requirements, and supported team meetings for the Environmental Control Life Support Systems (ECLSS), GLAST Burst Monitor (GBM), Material Science Research Rack (MSRR), Solar-B, and Microgravity Science Govebox (MSG) projects. QE continued review and provided comments for safety verification closures for ECLSS. QE provided quality expertise to Material Review Boards for ECLSS, MSRR and MSG.

QE continued to provide support to the DART Spacecraft failure investigation. QE continued to assist in the formulation of a Preliminary Mishap Investigation Board, (MIB), including implementing the approved DART Mishap Investigation Procedure. QE was responsible for the impoundment of all inventories in the Mission Operation Center and its subsequent delivery to MSFC for reference information to the formal MIB. Since the mishap, QE has assisted the DART MIB Chairman in all the logistics required to conduct the mishap investigation review in a timely manner.

Inspection and Test
Quality Assurance (QA) personnel continued support to the ET / SRB RTF testing and inspection activities. QA personnel continued to support the manufacturing, and inspection of ET Foam test specimens. QA personnel continued to witness the application of Hypalon onto Hentzen topcoat qualification test panels.

QA personnel supported the ECLSS Project with: (1) inspection and data review activities. Inspecting/reviewing work orders and data for the Distillation Assembly, Water Recovery System (WRS) Rack, and the OGS Rack Assembly sub-tier work orders; (2) monitored PCH moves of Rack #1; and, (3) inspected/reviewed the WSTA Qualification Unit Acceptance Data Package.

QA personnel supported the Microgravity Science Govebox (MSG), Material Science Research Rack (MSRR), Lab-On-a-Chip (LOCAD), Solar-B, g-LIMIT, and GLAST Burst Monitor (GBM).

QA personnel provided hardware inspection, test surveillance and document review support to the following QD10 projects: External Tank RTF Testing, 24" Solid Fueled Motor High Pressure Grain Test, and weld inspections on the new facility gaseous hydrogen piping at Test Stand 115.

Receiving inspection was performed on hardware for multiple flight projects, assuring compliance to all requirements.

4.4 Information Management (IM)

During the quarter, Information Management (IM) significantly modified numerous applications, improving both user and internal processes. IM rewrote the Supervisor Safety Web Page

(SSWP), updating the application software and incorporating internal and user-requested improvements. Three programs that update personnel data for SSWP from the center's personnel data were also rewritten to remove unneeded fields and improve functionality. The Safety, Health and Environment Tracking (SHETRAK) application was also revised to incorporate supervisor findings, and Safety Search was modified to provide finding data. SSWP will also provide supervisors a means of assessing SHE training requirements for all employees through the SHE Training Catalog application that will be deployed with SSWP. The revised SSWP functionality will be beta tested in January, 2006 and deployed in February. The PRACA application and database were revised to incorporate changes requested by the SSME community. Changes to date fields and reports were required because of the SSME contractor's unique use of data fields. PRACA was also revised to provide RocketDyne connectivity for automated reporting and to automate notification. The database was upgraded, a new Shuttle project was added, and changes to administrative functionality were included. SHEtrak was also modified to create a Contracting Officer's Technical Representative (COTR) role that allows view of construction findings assigned new role in the SHEtrak application. All screens were changed to display the contractor/ Field Work Request (FWR) and subcontractor fields as well as the name of the COTR. Certification Tracking (Certrak)was modified to improve notification of medical status change. IM released a new version of the S&MA Customer Survey application. The application now tracks the type of survey (solicited or unsolicited). The Space Flight Awareness (SFA) website was revised to reflect the Expedition 12 crew. IM also rewrote the As-Built Configuration Status System (ABCSS) to improve functionality and to replace outdated software. After the code has been fully tested internally, a beta test will be coordinated with the customer. IM also modified the field size for stamps in the production system. Changes were made to the database and the various forms that contain the stamp field. IM deployed some rewritten ABCSS report functionality in the new language to incorporate a bug fix. IM also incorporated numerous modifications into the application development common framework libraries. Modifications to the common framework improve security and consistency in database development methods as well as save manpower by programming functions, such as graph generation, in one location that can be called throughout S&MA's web-based applications, significantly reducing manpower to program and maintain functionality.

IM provided data to the Information Technology Manager (ITM) in support of data calls. IM submitted IT application inventory data to a database managed by the Office of the Chief Information Officer. The data supports development by NASA headquarters of an implementation plan for Federal Law HSPD-12, which sets the Nation's policy for a Common Identification Standard for Federal Employees and Contractors. IM also provided IT support data for the FY06 Federal Activities Inventory Reform (FAIR) function, which assists Executive Branch officers and employees in avoiding an unacceptable transfer of official responsibility to Government contractors. IM also modified the QD Web Products application security plan as well as a security plan for a non-ODIN computer managed by S&MA. IM also completed an MORR for release of the Independent Assessment Database (IADB) and the Safety, Health and Environmental Training Catalog (STC) applications. IADB was approved for release. STC was approved pending approval of the associated record plan; revisions are being coordinated with the MSFC Record Manager. STC, which will provide supervisors a means of assessing SHE training needs for employees, is planned for deployment with deployment of the SSWP

application in early 2006. IADB, which is used by the Independent Assessment group to status in-process assessments, has been released.

4.5 Human Exploration and Development of Space (HEDS) Assurance

The Independent Assessment (IA) Management Information System Database is used as an information conduit with our NASA customer. The IA analyst for each element updates the entries as changes in issues, concerns, and status, for that element occur. The HEI Information Technology team has updated the database to be web-based and more user friendly. Currently, the IA analysts are inputting data into the database. Most of the Engineering Information Reports formerly accessed on the u-Drive in a non-user friendly manner have now been up-loaded to be accessible to our NASA customer through the IA database.

4.5.1 Space Shuttle Independent Assurance

A draft report of the IA MH-4007, Procurement Quality Control of the United Space Alliance's (USA) SRB has been in internal review waiting on responses to the findings and observations which were presented to the SRB project. The project was requested to supply responses by October 16, 2005. So far, there have been no responses submitted to IA by the project, so the report is still in draft form. During the assessment of the United Space Alliance's (USA) Solid Rocket Booster Procurement Quality System, the IA Analyst was not allowed to perform a site visit to the United Propulsion Co., Inc (UPCO) facility without a substantial payment to UPCO. At that time, it was deemed not essential to force the issue. Since that time, USA planned an Annual Supplier Quality Maintenance Survey of UPCO and the IA Analyst was able to accompany the USA team to UPCO. As the UPCO assessment was performed in conjunction with the USA team, the typical IA process was not used. USA expects responses to observations and findings at the outbriefing of the assessment. Due to this different process and due to the UPCO audit being a USA audit rather than a MSFC S&MA audit, an addendum to the assessment report was written to incorporate the UPCO observations and findings and the responses to these observations and findings.

Part of NASA Headquarters expectations for MSFC IA is to support their newly instituted Program Analysis and Review (PA&R) process. Several months ago they began what they termed as Phase I with the RSRM project. MSFC IA was not able to be integrated into that activity. NASA Headquarters has now begun Phase II of this activity and MSFC IA is involved. It was hoped that the MSFC IA task to assess all the propulsion elements procurement quality systems would be able to use this RSRM PA&R as the basis for the assessment. Unfortunately, it was felt that the scope of the PA&R did not include some of the activities desired for the IA of the RSRM procurement quality system. When the PA&R is substantially complete, IA will determine what further assessment is reasonable.

Prior to the STS-114 flight, the IA Teams from both the JSC and MSFC presented a dissenting opinion to the Space Shuttle Programs decision to not further investigate the interface between the T-0 umbilical connector and the Shuttle Orbiter. As a result, the program was to perform further testing and analysis on this interface after the STS-114 flight. The IAT attended the Program Requirements Control Board (PRCB) meeting to make the decision on the additional analyses to be performed and the instrumentation to be added. The PRCB decision was to implement a portion of the instrumentation and perform some of the additional analyses

recommended by the IAT. The Program felt that the additional recommended items did not increase the understanding of the interface enough to justify the additional cost.

During the launch of STS-114, the ET lost Thermal Protection System (TPS) Foam to an unexpected extent. Investigation teams were set up to determine the root cause (s) of the foam loss and potential ways to verify the integrity of the foam application prior to launch of the shuttle. The IAT was primarily involved in the investigation of foam from the Ice Frost Ramps (IFR), but has been monitoring the progress and decisions of the teams addressing the other areas of foam loss. With the exception of the IFR, the IAT feels that the program is on an appropriate track to be able to apply the foam and to insure its integrity. In the case of the IFR, the root cause is not yet understood and methods to determine the integrity of the IFR foam on the existing ETs. The IAT has recommended that the program: (1) insure that there is an adequate certification program for the foam; (2) perform sufficient testing to insure that the critical parameters for the foam (i.e., void content and location and bondline integrity) are understood well; (3) develop non-destructive evaluation and statistical techniques to insure that the critical parameters remain in bounds; and, (4) insure that there are adequate process controls in place to insure that the foam application processes are documented and performed per the documentation.

4.5.2 Space Launch Initiative Independent Assurance

The IAT participated in the Crew Launch Vehicle (CLV) Design Analysis Cycle – 1 (DAC – 1) Kick-off Meeting. The DAC – 1 will include analyses necessary to support the Systems Requirements Review to be held later this year. There were no obvious concerns which would warrant any IA activities other than following the progress of the analyses.

The IAT is reading the Explorations Systems Architecture Study report and the draft Exploration Mission Systems Division developed technical and programmatic requirements to enable meaningful assessments and reviews of the associated programs and projects.

4.6 Project Assurance

Project Assurance Engineering (PAE) completed review of the Engine Development Plan. The primary objective of this activity is to demonstrate deep-throttling (10:1 initial, ultimate goal 20:1 deep throttling) capability of a modified RL-10 engine for possible application on future programs. There were contradictory statements in the turbomachinery section as to methodology for reducing LOX injection delta pressure. Project Assurance has requested clarification on which methodology Pratt & Whitney would use to achieve the stated goal. Additionally, PA asked the contractor to provide rationale to support their decision to forego running cold flows on the propellant feed system up to the engine/test stand interface.

PAE traveled to WSTF to provide S&MA support for the cold flows test readiness review. A number of action items were assigned to WSTF, the majority of which being editorial in nature requiring little more than specification, hazard and FMEA updates. Valve leakage was of concern and, following MSFC/WSTF discussions with the manufacturer (TYCO), a decision was made to replace the discrepant valves on the forward and aft feed system purge lines with Marotta MV100s with dual check valves. The replacement valves were sent to the valve shop for cleaning and the WSTF Oxygen Hazards Group was advised to review the proposed configuration change for potential hazards impact. The Hazards Group was also to review a

revised risk assessment statement, prepared by MSFC Project Management, to evaluate the impact of leaving the discrepant valves in the flow simulator and accepting the leakage risk. Any leakage through these valves vents into a safe dump line and discharges into the flume area, well away from the test cell but, since these valves are used for thermal control of the respective manifolds, thermal control in relation to expected data would be adversely affected. However, worst case analysis indicates the leakage rate would be significantly less than full-open flow rate, which is the valve position when venting for the purpose of thermal control so, impact on thermal cycling would be minimal.

While on site at WSTF for the cold flow Test Readiness Review, PAE personnel observed that plywood was being used to bridge the area between the test article and work platform, providing easy access to valves above the test article. Despite assurances that the material would be removed prior to proceeding, cold flows were conducted with numerous leaks observed, possibly saturating the material with oxygen and later, ethanol.WSTF S&MA, rather than order the material removed, instead cautioned technicians from walking on the plywood. Concern is that a majority of the team working this effort at WSTF is not fully certified to work in oxygen systems and therefore, does not have sufficient background to fully appreciate the hazard potential (completion of cold flows is the last step in the certification process). In addition, the Reaction Control Engines were accepted and shipped to WSTF with an open non-conformance on the engine #3 fuel valve that failed during Option 1 testing at Aerojet (unseated valve). The n/c was investigated by Aerojet, MSFC, WSTF/JSC and the manufacturer (MOOG Valves), and procedural steps taken to prevent a recurrence during final testing at WSTF. A detailed Risk Assessment Statement was also developed and accepted by all concerned parties. Aerojet had not yet submitted their closure rationale to complete the Acceptance Package so this remained a constraint to hot-fire testing.

Engine cold flows began on November 3, 2005 with minor leakage detected when the aft feedline to the engine was "wetted." WSTF will begin repairs immediately and implement additional procedural modifications prior to the resumption of cold flows during the week of November 7. 2005. Overall, the results were encouraging. PAE has once again asked Aerojet to submit their rationale for closing a fuel valve non-conformance on Engine 3 which occurred during option 1 testing. Engine 3 was accepted and shipped with the open non-conformance with the understanding that closure rationale would be submitted prior to cold flows. To date, Aerojet has not submitted rationale to close the non-conformance and thereby, complete the acceptance package. While the investigation yielded little or no evidence sufficient to positively pinpoint the failure cause, Aerojet, JSC, MSFC and a team at MOOG believe we fully understand the underlying causes and unanimously agree that proper mitigation has been implemented to preclude a recurrence. However, until the closure rationale is submitted, the open non-conformance is considered a constraint to hot-fire testing.

PAE continued to support the development and assessment of the agency's S&MA Policy and requirements documents to determine which requirements are by their nature Programmatic and which are Technical. A companion effort was carried out to also develop rationale as to why requirements were judged to be either Programmatic or Technical. The completion of both of these tasks will allow a better understanding of the requirements and how they should be included in future NASA programs.

PAE reviewed the Crew Launch Vehicle/Launch Management System Integrated Requirements Document, CLV/LMS IRD to assure compliance with S&MA requirements. In addition, PAE reviewed the Crew Launch Vehicle Project System Engineering Management Plan and provided comments to QD11.

PAE is reviewing the Crew Launch Vehicle (CLV) fault tree charts developed by the System Safety team to evaluate its contents and to make applicable recommendations and comments. In addition, PAE reviewed the CLV Integrated Vehicle Configuration Definition document as an additional source of information for effective evaluation of the CLV fault tree.

PAE supported the Integration Team in generating the CLV Flight Safety Systems Integrated Requirements document. In this effort, a team of various applicable disciplines was formed to assist in satisfying the Range Safety requirements and those of CLV Flight Safety Systems. Membership extends to include individuals from JSC and KSC. A weekly meeting is being held to achieve the intended purpose. In addition, PAE participated in a meeting for evaluation of the CLV Functional Flow Block Diagram (FFBD). Although it should have assisted in the development of the requirements, FFBD is being used as a tool for assuring completeness of the CLV requirements at the various levels of CLV development (System, subsystem, element, etc.).

PAE continues to oversee and coordinate S&MA activities for TEM-12. Safety Engineering provided the safety assessment of the proposed full scale TEM-12 motor. The firing is to unload the propellant from motors sent back from KSC due to the accident and subsequent launch delays. The age life of the propellant is closing in on the five-year requirement. This test will not gimbal the nozzle and has only ballistic review as an objective. ATK Thiokol has proposed using a non flight exit cone. This was thoroughly assessed by HEI safety with an approval to test recommendation. This TEM motor tests will continue to occur until a routine flight schedule is obtained.

PAE participated in the Shuttle Environmental Assurance (SAE) Face-to-Face in Huntsville, AL. At the Face-to-Face, PAE participated in various discussions on environmental regulations that may result in the obsolescence of materials used in the Space Shuttle Program. Members of SEA also work to exchange information and data on materials replacements, pollution prevention, and Shuttle environmental impacts.

PAE reviewed and submitted comments to the verification approach document for in situ parts repair and fabrication at destination sites such as the moon and Mars. As part of this activity PAE participated in meetings on the document's development at Teledyne Brown Engineering (TBE). These activities were conducted in support of the ISFR Repair and Non-Destructive Evaluation (NDE) team. That document is now out for NASA review. The key challenges are how does NASA qualify process and accept parts for parts repair and fabrication at destination sites without the full range of facilities, test equipment and personnel available to ground-based production and repair. This is of particular concern for critical parts produced from in situ derived source stock. The approach envisioned would rely heavily on remote monitoring processes, NDE, coupon testing of materials derived from in situ resources, and analysis.

PAE assessed S&MA requirements applicability to *In Situ* Fabrication and Repair (ISFR) activities for both the fabricators and products to be produced on the moon and Mars. For products produced on the moon or Mars the PAE analyzed these requirements from the stand point of will they impact the design of materials and parts derived from in-situ resources from the moon, Mars, asteroids, or other Constellation Program destinations in addition to fabrication using terrestrial source stock. To this end the PAE submitted spreadsheets to the ISFR Habitat Team Lead Systems Engineer (LSE) with the analysis of these S&MA requirements applicability. The PAE participated in meetings with HAB Lead Systems Engineer (LSE) on S&MA requirements analysis. This analysis is intended to support the derivation of S&MA requirements for lunar surface fabricators, habitation modules, and parts produced at the destination site.

4.7 Risk Management and Risk Assessment

4.7.1 Continuous Risk Management (CRM)

During quarter Continuous Risk Management's (CRM) support to QD20 continued through its participation in the Contract Management Module (CMM) Non-Advocate Review (NAR). The System Management Office had requested a member of the QD40/CRM Team to be a member of the CMM NAR and to assess the CMM Risk Management effort. This portion of the CMM NAR Assessment concerns itself primarily with the Risk Management aspects of the Contract Management Module Project. CRM met with members of the CMM Project Team on two separate occasions to discuss the Continuous Risk Management Process within the CMM Project and members of the CMM Project Team provided a demonstration of the CMM Risk Database (MDM) that the project uses to document CMM Project Risks. In addition, a detail review was conducted of the following documentation to support this assessment: Contract Management Module (CMM) Project Plan (Draft v5), Integrated Financial Management Program (IFMP) Program Plan, ASIPO Risk Management Plan (Final), Program Risk Management Framework, IFMP Project Quarterly Risk Review, Monthly Status Report (MSR) IFMP CMM and CMM Schedules.

CRM continued as an active member of QD40's CAIB/Diaz Action Digital Close-Out Photography (DCOP) Assessment Team from MSFC this quarter. The objective of this team was to help establish digital close-out photography requirements throughout the agency once all reviews and results had been presented to NASA HQ. The team was organized in order to bench-mark the many NASA/DoD contractor facility's (e.g. Lockheed-Martin in Sunnyvale, CA, Jet Propulsion Lab in Pasadena, CA, Boeing at KSC in FL and Raytheon in Andover, MA.). A final assessment report was completed and successfully presented September 9, 2005 to NASA HQ in Washington, D.C. As a result of these efforts NASA HQ has requested that follow on actions within the NPD 8730.x draft, include a "NASA Quality Assurance Program Policy". This policy will assure that all NASA programs, projects and Centers utilize DCOP consistently, and to the maximum extent possible. CRM has reviewed the NASA Programs/Projects current policies and capabilities associated with configuration control, closeout photographs, and engineering drawings. It also determined that the NASA Programs/Projects implemented policies, met the intent of the Columbia Accident Investigation Board (CAIB) recommendation. CRM was also tasked this quarter to assess the findings from the DCOP site visit in order to verify whether NASA should include them within the NPR 8730.x draft. CRM has completed its review of the DCOP Team's recommendation for requirements that are to be included in the

NPR 8730.x draft, NASA Quality Assurance Program Policy Document. In addition to the review RM has since provided comments and signed off on the final/baseline version of the DCOP Final Report.

CRM revised and enhanced the CRM Class Documentation spreadsheet this period. This spreadsheet (used as a tool) tracks the following CRM course information: Type of Course, Name of Students, Student's Organization and Date of Course. Enhancements include course color-coding and a sorting capability of student, class attended or date attended. This tool will help document all CRM training as part of the NASA/HEI Personnel Certification effort. Additionally, a review was conducted on all critiques and CRM certificates. This review identified numerous comments for enhancement to the CRM courses and these critiques will be considered for implementation on the next CRM course revision effort, targeted for the second quarter of FY 2006.

CRM reviewed and documented all processes involved as part of the MSFC RMMM assessment process. This in-house, lessons learned effort captured all documentation, process flows and data collection procedures utilized in the current assessment effort. The rationale for this is capture effort is to determine what works or doesn't work and how to refine the RMMM assessment process. These findings are now linked to the CRM requirements identified in NPR 8000.4 and NPR 7120.5 for a more concise CRM assessment process. This product was completed for review in mid-November 2005.

The CRM Team revised and enhanced the CRM website this quarter to include updates to CRM Team personnel, restructuring of the format for better process flow and updating government, industry and academic web sites that are related to Risk Management. This information will enhance the CRM process by illustrating the standards that government, commercial and academic identify and implement as part of the risk identification process. Also included in the update is a direct link to a CRM class scheduling tool, and a web site hit counter, to determine the number of personnel interested about the CRM process.

CRM was tasked with supporting the Electronic Project On-Line Reporting Tool (ePORT) Users Group Meeting conducted by MSFC/QD40, on November 2, 2005. The topics discussed included: ePORT Upgrade; ePORT Capabilities, Risk Waterfall Charts, and Problem Reporting vs Risk Reporting. ePORT is used by numerous MSFC projects and is very effective in documenting project risks. CRM also conducted a top level Risk Database Assessment including: Electronic Project On-Line Report Tool (ePORT), Integrated Risk Management Application (IRMA), Shuttle Integrated Risk Management Application (SIRMA), and Active Risk Manager (ARM). The goal of this assessment is to develop a comparison of Pros and Cons for each of the four Risk Data Bases described and provide this information to the S&MA Director. This report will also establish guidelines and standards for risk documentation and risk reporting.

The MSFC PMC approved S&MA/QD40's proposal to conduct a Phase III Risk Management Maturity Assessments (RMMA) for the following MSFC Projects:
ISS Regenerative ECLSS (ECLSS), In-Space Propulsion Technology Project (ISPT), First Materials Science Research Rack (MSRR-1) and the Auxiliary Propulsion Project (APP). After

all RMMA's were conducted the ISS Regenerative ECLSS (ECLSS) out-brief presentations was given to the MSFC PMC in September 2005, both the First Materials Science Research Rack (MSRR-1) and the Auxiliary Propulsion Project (APP) were presented in October 2005 with the In-Space Propulsion Technology Project (ISPT) out-brief presentation given in November 2005.

The S&MA/QD40 CRM Team was tasked to provide CRM Training in-house to MSFC employees and contractors. The Executive Overview CRM course with workshop re-familiarizes the student with the fundamentals of CRM. It is provided to project members who have had CRM training in the past but have not been active in its implementation. The areas of discussion focused on the following: (1) Risk Identification; (2) Analyzing Risks; (3) Plan; (4) Track; (5) Control; and, (6) Communicate and Document Risks. The CRM Team conducted its latest Executive Overview Training Course with Center personnel during the last week of November 2005.

The CRM Team supported NASA's Risk Management Conference (RMC VI) this quarter in Orlando, Florida. The purpose of the conference was to bring the Risk Management community together in order to exchange/share information. In addition, S&MA/QD40 also presented the MSFC's Risk Management Maturity Model Assessment Process to members attending the RMC VI Conference.

CRM presented a CRM overview to NASA's Quality Assurance (QA) Group represented by S&MA's QD40. Topics included were: Why do CRM; What the CRM Paradigm means; and a brief overview of the CRM process. QA's response to the overview was enthusiastic and involved. An interest was expressed by QD40 in conducting a series of CRM related classes to ensure that QA personnel help program/project management identify program/project risks at the lowest possible level.

The S&MA/QD40 CRM team provided support to the ST9 Solar Sail Project (SSP) in the development and preparation of the Risk Management Plan. The Statement of Work included the following elements for Risk Management Support of the ST9 Solar Sail Project: Develop Risk Management Framework for the Sail Propulsion System (SPS) of the ST9 Solar Sail Flight Validation by 12/31/2005; organize the ST9 Solar Sail Risk Management Plan in order to be compatible with Goddard Space Flight Center's risk management requirements and the New Millennium's risk management processes; establish a risk matrix ranking and scoring process by 3/15/2006 and implement/maintain the risk matrix scoring/ranking process for SPS by 9/30/2006; develop Failure Effects Analysis of ST9 Solar Sail Project as appropriate for phase A of the ST9 SSP by 4/15/2006; provide risk input to and participate in the Integrated Mission Design Center mission engineering analysis for the SPS of the ST9 Solar Sail mission by 3/2006; support ST9 SSP Phase A study and generate study risk reports as needed by 9/30/2006. The CRM Team submitted the first Draft of the ST9 Solar Sail RMP to the NASA/QD30, S&MA Lead for the ST9 Solar Sail Project, on December 28, 2005.

CRM was tasked this quarter to review all of NASA's risk requirements in order to identify what requirements are affiliated with the MSFC CRM triangle: Facilitation, Assessment & Training. Work is currently in progress to identify these requirements and link them to the specific areas of the CRM charter, where a more structured processes can be developed for the assessment and

facilitation efforts also under way by the CRM Team. The Requirements Spreadsheet will be linked to the CRM website for access by all MSFC programs/projects to aid them in identifying what requirements are to be implemented in risk management plans and processes.

HEI's CRM presented NASA's CRM process overview to the North Alabama Chapter of the Project Management Institute (PMI) December 2005 luncheon. This overview covered the basic elements of the CRM paradigm with an emphasis on how identified risks impact project decisions.

4.7.2 Space Shuttle Probabilistic Risk Assessment (PRA)

Probabilistic Risk Assessment (PRA) was tasked with supporting System Safety by creating an initial fault tree for the CLV Project; due for a January 2006 review. PRA also met and discussed changes to be made to the CLV fault tree before meeting with MSFC S&MA. These changes have been completed and the team is now waiting for input from MSFC S&MA.

PRA has reviewed and edited the latest draft of the SPRA phenomenological report this period as well as providing comments to the other MSFC PRA team members. PRA also performed an initial review of the revised generic prior distributions from JSC using updated generic data methodology and held a telecon with JSC on SSME abort modeling status and upcoming tasks. PRA was tasked with reviewing a draft Shuttle PRA briefing chart for NASA's Administrator and provide feedback to QD40.

PRA has been working with JSC's tech writer to incorporate comments and changes to the Iteration 2.0 PRA documentation by making noted editorial changes, importing new pictures into the SRB System Notebook (per SRB Project office and USA), verifying that the JSC tech writer had the latest functional appendices for Iteration 2.0 documentation and corrected references listed in the Shuttle PRA Iteration 2.0 Notebook.

In preparation for Iteration 3, PRA began examining the various techniques for quantifying the reliability improvement of the SSME Advance Health Monitoring System (AHMS) Phase I for the Iteration 3 SSME PRA this quarter. One technique examined was the grouping of the current SSME catastrophic failures into one likelihood function and re-discounting the failures to directly to Block II with AHMS Phase I configuration. Another technique examined was the use of engine level AHMS improvement factor, similar to the Block II environment and hardware factors currently used. The final improvement factor used, if desired, will be based on discussions with SSME engineers and current AHMS qualification test data. The current SSME PRA's Excel spreadsheet with Visual Basics for Application (VBA) code has been modified to implement these two techniques.

PRA also met with S&MA and the SRB Project Office as well as the rest of the Shuttle PRA Team (SPRAT) at JSC in November to discuss the list of actions for the SRB Iteration 3 and to kick off this new PRA effort. The two-day Shuttle PRA TIM at JSC discussed the Shuttle PRA Iteration 3 modeling items and issues. Such items and issues discussed were Iteration 3's SRB PRA which will mainly consist of model refinements to the logic model, BSM crack throat model and APU leaks; Advanced Health Monitoring System (AHMS) Phase I and expanded

hydraulic and electrical lockup models, new conditional failure probabilities for abort operations and the status of the ET leak methodology review.

PRA completed two draft versions of its technical papers and submitted them for review this quarter to Pratt and Whitney Rocketdyne concerning the SSME PRA methodology and the ET PRA leak analysis methodology for the upcoming conference on Probabilistic Safety Assessment and Management (PSAM-8).

PRA supported QD40's PRA Lead this quarter in developing a Shuttle PRA level-of-effort preliminary estimates which is broken down by element and subtask for FY2006. The estimates were requested by JSC/NC's SPRA Lead. PRA also performed a quick Crystal Ball simulation for CLV risk cases for QD40.

4.7.3 Shuttle Reliability, Prediction & Risk Analysis

During the this quarter Risk Assessment (RA) was tasked with helping implement a reinforced carbon-carbon on-orbit crack repair (ROCR) viscosity sensitivity test matrix. This test was the result of significant differences seen in usefulness due to viscosity variability in the compound to be used for repairing Orbiter wing leading edges and other areas during on-orbit testing. It was determined that raw materials going into the compound were the cause. RA helped to implement a test matrix designed to identify which ingredient was the culprit and then analyzed the results. The design was a design of experiments (DOE) matrix, completed in 8 mixes. On analysis, the data clearly showed that one particular component, one different from that expected, was solely responsible for the viscosity increase in this case. Results also showed no apparent important effect from the other tested components or from any interaction between components. A first designed experiment (DOE) follow-on test using two different lots of raw materials using the same test matrix, randomized differently was successful in pinpointing the cause of the problem as a particular lot of a particular ceramic ingredient. A DOE using different lots was performed to see if a similar problem was due to the same cause. While the results were somewhat less conclusive, it was shown to be likely that a different cause of high viscosity was involved, one that was not a factor in this test. The results were presented to the Integrated Product Team (IPT) for review and were well received. However, this DOE clearly pointed to the large effect of differences between batches of one ingredient, a zirconium compound, and hinted that an interaction between zirconium and another component may or may not be of additional concern. A fault tree had been constructed to organize knowledge and frame questions surrounding causes of viscosity variation. RA wrote a partial closure statement for general blocks on the interaction effect, pointing out that the DOE was not sensitive enough to determine a low-level interaction as cause for viscosity variability, but it was also not sensitive enough to be able to rule out interactions – or single components by themselves – at the same low level of effect. A larger test would be necessary to refine knowledge if these smaller effects were truly important. Further, the test was not an all-inclusive examination of causes, and only addressed the specific lots investigated in the test; in fact, it did not uncover the cause of the difference between two of the lots.

RA was tasked to develop a thermography method this quarter in order to isolate the location of many leaks to specific spots of one or two tubes on the SSME nozzle. This new method was the result of the SSME's nozzle cooling tubes occasionally developing leaks serious enough to

require repair and the fact that the specific leaking tube is often difficult to isolate. This results in opening a sometimes large number of tubes to find the leak, which is a large and expensive effort. The method developed does not affect mission risk, but does reduce wasted time and resources. S&MA has actively and materially participated in meetings discussing test plans, test articles and customers, requirements and methods for certification. S&MA has also been instrumental in keeping the line drawn between this waste-preventing shop aid and methods used for certifying a nozzle free of leaks for flight.

RA was also tasked this quarter with characterizing a third ET Hardpoint (THP) Closeout Shearography method due to a portion of the ET tank foam being applied at KSC in order to cover an area left bare for handling ability. Earlier proposals were to use the nondestructive evaluation (NDE) method shearography to look for unbonded foam and other flaws in this region and others. RA presented a range of test scenarios to the team based on meeting specific test goals with consideration given also to constraints of resources. In addition RA provided a demonstration showing the benefits of taking data outside the range within which the detection limits should lie in order to best characterize the detection limit (breaking the process). RA presented a more focused range of test scenarios to the team based on meeting specific test goals considering constraints to resources. RA remains a participant in writing the overall long- and short-term goals for the team with rough test outlines and milestones for eventual NDE method certification.

RA provided a Flow Liner Crack Nondestructive Evaluation (NDE) Probability of Detection (POD) on the SSME element this quarter. Cracks in flow liners could result in liberation of dangerous FOD upstream of the SSME's. RA is part of the team evaluating the "goodness", measured in terms of POD, of NDE methods in measuring these cracks. RA is rechecking and writing up final findings on the analysis of manufactured flaw data. RA has assembled the new data, coming in from tests on simulated hardware containing realistic flaws and is now analyzing it.

SSME ultrasonic fastener stretch measurement equipment is being updated by relating Erdman counts to load then to relating load to delta time. RA was tasked to analyze the data for this testing. The main testing is being performed at Canoga Park and MSFC is performing a portion of the testing here to evaluate differences in location and to assure the accuracy of the readings at Canoga Park. New fixtures for the testing have been made and verification testing has begun. Testing of the 0708 bolt is now complete. RA analyzed the 0708 data and presented the results to the team. A new lower insert was machined and the 0937 bolt was retested. Test results from the 0937 bolt were determined to be unsatisfactory to the Erdman team. A new lower insert was machined and both insert sets have been retested. RA has analyzed the 0937 retest data and presented the results to the team. The location verification testing was begun with Canoga Park's portion of the part 1c testing being completed and the bolts being shipped to MSFC for testing. The 0506 bolt has been retested several times and RA is currently reviewing the results which are to be discussed with the team. RA is also reviewing the Part 2a test plan and lab test procedure and will offer recommendations to the team when review is complete. Data was also collected on Engine 0525, Engine 2059 and Engine 2058 using both the Erdman and Norbar machines. RA is presently compiling the databases in order to analyze the results.

RA has been evaluating ways to determine tolerances on reliability predictions for practical systems. RA recently found two good examples in the technical literature that can be used to illustrate math and procedures to be used. These can also be used to independently investigate various software programs that do reliability calculations.

RA has reviewed the test report from ATK on low temperature O-ring tests. O-ring segments were made from special material formulation in order to study resiliency at low temperatures. Results produced a successful demonstration of the splice strength at a low temperature of approximately 50° F. RA also provided comments on temperature measurement tolerances and statistics concerning the difference of means (averages).

RA is presently researching reliability predictions in preparation of work on the Crew Launch Vehicle (CLV). Since one of the fundamentals is the relevant failure rate of the various system components sources of this information are being sought.

RA evaluated the "RMAT, Reliability and Maintainability, MAT, Training Manual this quarter for its usefulness in reliability work for the new crew launch vehicle (CLV) program. RA's main concern is to find failure rates for various components to be used.

RA attended several sessions at the American Society for Quality (ASQ) Fall Technical Conference. The conference included an extended session on Design of Experiments (DOE) involving hard-to-change test factors. Other sessions attended included: SPC on censored lognormal observations; improving multivariate SPC charts; use of single-sample advanced SPC chart types (exponentially weighted moving average EWMA and cumulative sum CUSUM charts); common data analysis errors; response surface analysis (RSA); improved methods for comparison of two measurement devices; and supersaturated DOE designs, which screen a large number of factors in a relatively small number of trials (say, 18 factors in 16 trials). The information gained will be directly applicable to ongoing and future NASA processes.

In addition to presenting recent ROCR viscosity test data to MSFC S&MA and participating in discussions regarding validation of SSME nozzle tube thermography, RA also attended a reliability seminar presented by reliability software manufacturer Reliasoft. RA attended sessions on the applied mathematics of reliability, accelerated testing and block sequence diagrams and systems analysis. Emphasis was placed on distribution fitting, confidence interval calculation, graphical analysis, suspended data (trials ended before failure occurs), multiple failure modes, repairable systems and other topics. Practice was given using their highly useful software. RA saw application to areas not directly related to reliability as well, including material shelf life studies, stress-strain analysis, multiple stressor characterization (e.g., studies of effects of temperature, vibration and bending stress) and probability of detection (POD).

4.7.4 Advanced Projects Risk Assessment

During this quarter RA continued its support to Advanced Projects (QD10) by modeling applicable SRB failure modes with the intention of performing a PRA on these models once completed.

RA worked with HEI's IM, to perfect a "canned" presentation/demonstration of the Statistical Tool For Assessing The Risks Of Space Exploration (STARS) tool from start to finish. RA then gave a detailed briefing to S&MA QD10 management, the QD40 staff and the Constellation Launch Vehicle Program System Engineering and Integration (SE&I) management. Funding requirements needed for a baseline version of the tool were also presented, along with a schedule and Work Breakdown Structure (WBS).

RA began work on providing a full Main Propulsion System (MPS) model to aid Glenn Research Center's (GRC) CEV Orbital Maneuvering System and Reaction Control System (OMS/RCS) engine trade study work this quarter. Once completed, the model will be populated with data, and a Probabilistic Risk Analysis (PRA) will be performed. RA also provided and examined subsystem reliability data for the Orbital Maneuvering System (OMS) engines, which was used in an overall CEV MPS model.

RA researched and created an allocation model for the Exploration System's Loss of Crew (LOC) requirement. Some of the analysis details and data require additional work at this time. One of the completed analyses, Probabilistic Risk Assessment (PRA), will be performed on the model in order to quantify uncertainty.

5.0 Cost Reduction Items

Our continuing cross-utilization of employees, continuous analysis of work in progress to assure that application of resources meets the needs of the task, and the judicial acquisition and distribution of tools to enhance the efficiency of all team members allow us to minimize cost to the customer.